

# L<sup>A</sup>T<sub>E</sub>X Math for Undergrads

**Rule One** Any mathematics at all, even a single character, gets a mathematical setting. Thus, for “the value of  $x$  is 7” enter the value of `$x$` is `$7$`.

**Template** Your document should contain at least this.

```
\documentclass{article}
\usepackage{mathtools,amssymb,amsthm} % imports amsmath

\begin{document}
--document body here--
\end{document}
```

## Common constructs

$x^2$  `x^2`       $\sqrt{2}$ ,  $\sqrt[3]{2}$  `\sqrt{2}`, `\sqrt[n]{3}`  
 $x_{i,j}$  `x_{i,j}`       $\frac{2}{3}$ ,  $2/3$  `\frac{2}{3}`, `2/3`

**Calligraphic letters** Use as in `$\mathcal{A}$`.

*ABCDEFGHIJKLMNOPQRSTUVWXYZ*

Get script letters, such as  $\mathscr{P}$  from `$\mathscr{P}$`, by putting `\usepackage{mathrsfs}` in the preamble.

## Greek

$\alpha$ <code>\alpha</code>	$\xi$ , $\Xi$ <code>\xi</code> , <code>\Xi</code>
$\beta$ <code>\beta</code>	$\circ$ <code>o</code>
$\gamma$ , $\Gamma$ <code>\gamma</code> , <code>\Gamma</code>	$\pi$ , $\Pi$ <code>\pi</code> , <code>\Pi</code>
$\delta$ , $\Delta$ <code>\delta</code> , <code>\Delta</code>	$\varpi$ <code>\varpi</code>
$\epsilon$ <code>\epsilon</code>	$\rho$ <code>\rho</code>
$\varepsilon$ <code>\varepsilon</code>	$\varrho$ <code>\varrho</code>
$\zeta$ <code>\zeta</code>	$\sigma$ , $\Sigma$ <code>\sigma</code> , <code>\Sigma</code>
$\eta$ <code>\eta</code>	$\varsigma$ <code>\varsigma</code>
$\theta$ $\Theta$ <code>\theta</code> , <code>\Theta</code>	$\tau$ <code>\tau</code>
$\vartheta$ <code>\vartheta</code>	$\upsilon$ , $\Upsilon$ <code>\upsilon</code> , <code>\Upsilon</code>
$\iota$ <code>\iota</code>	$\phi$ , $\Phi$ <code>\phi</code> , <code>\Phi</code>
$\kappa$ <code>\kappa</code>	$\varphi$ <code>\varphi</code>
$\lambda$ $\Lambda$ <code>\lambda</code> , <code>\Lambda</code>	$\chi$ <code>\chi</code>
$\mu$ <code>\mu</code>	$\psi$ , $\Psi$ <code>\psi</code> , <code>\Psi</code>
$\nu$ <code>\nu</code>	$\omega$ , $\Omega$ <code>\omega</code> , <code>\Omega</code>

## Sets and logic

$\cup$ <code>\cup</code>	$\mathbb{R}$ <code>\mathbb{R}</code>	$\forall$ <code>\forall</code>
$\cap$ <code>\cap</code>	$\mathbb{Z}$ <code>\mathbb{Z}</code>	$\exists$ <code>\exists</code>
$\subset$ <code>\subset</code>	$\mathbb{Q}$ <code>\mathbb{Q}</code>	$\neg$ <code>\neg</code>
$\subseteq$ <code>\subseteq</code>	$\mathbb{N}$ <code>\mathbb{N}</code>	$\vee$ <code>\vee</code>
$\supset$ <code>\supset</code>	$\mathbb{C}$ <code>\mathbb{C}</code>	$\wedge$ <code>\wedge</code>
$\supseteq$ <code>\supseteq</code>	$\emptyset$ <code>\varnothing</code>	$\vdash$ <code>\vdash</code>
$\in$ <code>\in</code>	$\emptyset$ <code>\emptyset</code>	$\models$ <code>\models</code>
$\notin$ <code>\notin</code>	$\aleph$ <code>\aleph</code>	$\setminus$ <code>\setminus</code>

Negate an operator, as in  $\not\subset$ , with `\not\subset`. Get the set complement  $A^c$  with `A^{\complement}` (or  $A^c$  with `A^{\complement}`, or  $\overline{A}$  with `\overline{A}`).

## Decorations

$f'$ <code>f'</code>	$\dot{a}$ <code>\dot{a}</code>	$\tilde{x}$ <code>\tilde{x}</code>
$f''$ <code>f''</code>	$\ddot{a}$ <code>\ddot{a}</code>	$\bar{x}$ <code>\bar{x}</code>
$\Sigma^*$ <code>\Sigma^*</code>	$\hat{x}$ <code>\hat{x}</code>	$\vec{x}$ <code>\vec{x}</code>

If the decorated letter is  $i$  or  $j$  then some decorations need `\imath` or `\jmath`, as in `\vec{\imath}`. Some authors use boldface for vectors: `\boldsymbol{x}`.

Entering `\overline{x+y}` produces  $\overline{x+y}$ , and `\widehat{x+y}` gives  $\widehat{x+y}$ . Comment on an expression as here (there is also `\overbrace{...}`).

$\underbrace{x+y}_{|A|}$  `\underbrace{x+y}_{|A|}`

**Dots** Use low dots in a list  $\{0, 1, 2, \dots\}$ , entered as `\{0,1,2,\,\,\ldots\}`. (If you use `\ldots` in plain text as with London, Paris, `\ldots`, then note the `\thinspace`, before the period.) Use centered dots in a sum or product  $1 + \dots + 100$ , entered as `1+\cdots+100`. You can also get vertical dots `\vdots` and diagonal dots `\ddots`.

**Roman names** Enter `\tan(x)`, with a backslash, instead of `tan(x)`. These get the same treatment.

$\sin$ <code>\sin</code>	$\sinh$ <code>\sinh</code>	$\arcsin$ <code>\arcsin</code>
$\cos$ <code>\cos</code>	$\cosh$ <code>\cosh</code>	$\arccos$ <code>\arccos</code>
$\tan$ <code>\tan</code>	$\tanh$ <code>\tanh</code>	$\arctan$ <code>\arctan</code>
$\sec$ <code>\sec</code>	$\coth$ <code>\coth</code>	$\min$ <code>\min</code>
$\csc$ <code>\csc</code>	$\det$ <code>\det</code>	$\max$ <code>\max</code>
$\cot$ <code>\cot</code>	$\dim$ <code>\dim</code>	$\inf$ <code>\inf</code>
$\exp$ <code>\exp</code>	$\ker$ <code>\ker</code>	$\sup$ <code>\sup</code>
$\log$ <code>\log</code>	$\deg$ <code>\deg</code>	$\liminf$ <code>\liminf</code>
$\ln$ <code>\ln</code>	$\arg$ <code>\arg</code>	$\limsup$ <code>\limsup</code>
$\lg$ <code>\lg</code>	$\gcd$ <code>\gcd</code>	$\lim$ <code>\lim</code>

## Other symbols

$<$ <code>&lt;</code>	$\angle$ <code>\angle</code>	$\cdot$ <code>\cdot</code>
$\leq$ <code>\leq</code>	$\measuredangle$ <code>\measuredangle</code>	$\pm$ <code>\pm</code>
$>$ <code>&gt;</code>	$\ell$ <code>\ell</code>	$\mp$ <code>\mp</code>
$\geq$ <code>\geq</code>	$\parallel$ <code>\parallel</code>	$\times$ <code>\times</code>
$\neq$ <code>\neq</code>	$45^\circ$ <code>45^{\circ}</code>	$\div$ <code>\div</code>
$\ll$ <code>\ll</code>	$\cong$ <code>\cong</code>	$*$ <code>\ast</code>
$\gg$ <code>\gg</code>	$\ncong$ <code>\ncong</code>	$ $ <code>\mid</code>
$\approx$ <code>\approx</code>	$\sim$ <code>\sim</code>	$\nmid$ <code>\nmid</code>
$\asymp$ <code>\asymp</code>	$\simeq$ <code>\simeq</code>	$n!$ <code>n!</code>
$\equiv$ <code>\equiv</code>	$\nsim$ <code>\nsim</code>	$\partial$ <code>\partial</code>
$\prec$ <code>\prec</code>	$\oplus$ <code>\oplus</code>	$\nabla$ <code>\nabla</code>
$\preceq$ <code>\preceq</code>	$\ominus$ <code>\ominus</code>	$\hbar$ <code>\hbar</code>
$\succ$ <code>\succ</code>	$\odot$ <code>\odot</code>	$\circ$ <code>\circ</code>
$\succeq$ <code>\succeq</code>	$\otimes$ <code>\otimes</code>	$\star$ <code>\star</code>
$\propto$ <code>\propto</code>	$\oslash$ <code>\oslash</code>	$\surd$ <code>\surd</code>
$\doteq$ <code>\doteq</code>	$\upharpoonright$ <code>\upharpoonright</code>	$\checkmark$ <code>\checkmark</code>

Use `a\mid b` for the divides relation,  $a \mid b$ , and `a\nmid b` for the negation,  $a \nmid b$ . Also use `\mid` to get set builder notation  $\{a \in S \mid a \text{ is odd}\}$ , with `\{a\in S\mid\text{\textit{\textit{a}} is odd}\}`.

## Arrows

$\rightarrow$ <code>\rightarrow</code>	$\mapsto$ <code>\mapsto</code>
$\nrightarrow$ <code>\nrightarrow</code>	$\longmapsto$ <code>\longmapsto</code>
$\longrightarrow$ <code>\longrightarrow</code>	$\leftarrow$ <code>\leftarrow</code>
$\Rightarrow$ <code>\Rightarrow</code>	$\leftrightharpoonup$ <code>\leftrightharpoonup</code>
$\nRightarrow$ <code>\nRightarrow</code>	$\downarrow$ <code>\downarrow</code>
$\Longrightarrow$ <code>\Longrightarrow</code>	$\uparrow$ <code>\uparrow</code>
$\leadsto$ <code>\leadsto</code>	$\updownarrow$ <code>\updownarrow</code>

The right arrows in the first column have matching left arrows, such as `\nleftarrow`, and there are some other matches for down arrows, etc.

**Variable-sized operators** The summation  $\sum_{j=0}^3 j^2$   
`\sum_{j=0}^3 j^2` and the integral  $\int_{x=0}^3 x^2 dx$   
`\int_{x=0}^3 x^2 \, dx` expand when displayed.

$$\sum_{j=0}^3 j^2 \quad \int_{x=0}^3 x^2 dx$$

These do the same.

$$\int \int \int \iiint \bigcup \bigcap$$

## Fences

$$\begin{array}{llll} () & () & \langle \rangle & \langle \rangle \\ [] & [] & \lfloor \rfloor & \lfloor \rfloor \\ \{ \} & \{ \} & \lceil \rceil & \lceil \rceil \end{array}$$

Fix the size with `\big`, `\Big`, `\bigg`, or `\Bigg`.

$$\left[ \sum_{k=0}^n e^{k^2} \right] \quad \Big[ \sum_{k=0}^n e^{k^2} \Big]$$

To have them grow with the enclosed formula, use `\left` and `\right` (although sometimes `\big`, etc., are necessary).

$$\left\langle i, 2^{2^i} \right\rangle \quad \left\langle i, 2^{2^i} \right\rangle$$

Every `\left` must match a `\right` and they must end on the same line in the output. For a one-sided fence, put a `\left.` or `\right.` on the other side.

$$\left. \frac{df}{dx} \right|_{x_0} \quad \left. \frac{df}{dx} \right|_{x_0}$$

**Arrays, Matrices** Make an array of mathematical text as you make a table of plain text.

$$\begin{array}{ll} 0 & \leftrightarrow 0 \\ 1 & \leftrightarrow 1 \\ 2 & \leftrightarrow 4 \\ \vdots & \vdots \end{array}$$

Definition by cases is an array with two columns.

$$f_n = \begin{cases} a & \text{if } n = 0 \\ r \cdot f_{n-1} & \text{else} \end{cases}$$

A matrix is an array with fences. With a `pmatrix` environment, you need not specify column alignments.

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

For the determinant use `|A|` inline and `vmatrix` in display.

**Spacing in mathematics** Improve  $\sqrt{2}x$  to  $\sqrt{2}x$  with a thin space, as in `\sqrt{2}\,x`. Slightly wider are `\:` and `\;` (the three are in ratio 3 : 4 : 5). Get the improvement of  $n/\log n$  instead of  $n/\log n$  by using a negative thin space, as in `n/\!\!\log n`. Bigger spaces are: `\quad` for  $\rightarrow \leftarrow$ , and `\qquad` for  $\rightarrow \leftarrow$ , which are useful between parts of a display. Get arbitrary space as in `\hspace*{0.5cm}`.

**Displayed equations** The `equation*` environment puts an equation on a separate line.

$$S = k \cdot \lg W$$

You can break into multiple lines.

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \dots$$

Align equations using `align*`

$$\begin{aligned} \nabla \cdot \boldsymbol{D} &= \rho \\ \nabla \cdot \boldsymbol{B} &= 0 \end{aligned}$$

(the left or right side of an alignment can be empty). For each environment, get a numbered version by dropping the asterisk from the name.

**Calculus examples** The last three here are display style.

$$f: \mathbb{R} \rightarrow \mathbb{R} \quad f: \mathbb{R} \rightarrow \mathbb{R}$$

$$9.8 \text{ m/s}^2 \quad 9.8 \text{ m/s}^2$$

$$\lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \quad \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

$$\int x^2 dx = x^3/3 + C \quad \int x^2 \, dx = x^3/3 + C$$

$$\nabla = i \frac{d}{dx} + j \frac{d}{dy} + k \frac{d}{dz} \quad \nabla = i \frac{d}{dx} + j \frac{d}{dy} + k \frac{d}{dz}$$

**Discrete mathematics examples** There are four modulo forms:  $m \bmod n$  is from `m\bmod n`, and  $a \equiv b \pmod m$  is from `a\equiv b\pmod m`, and  $a \equiv b \pmod m$  is from `a\equiv b\pmod m`, and  $a \equiv b \pmod m$  is from `a\equiv b\pmod m`.

For combinations the binomial symbol  $\binom{n}{k}$  is from `\binom{n}{k}`. This resizes to be bigger in a display (to require the display version use `\dbinom{n}{k}` and require the inline version with `\tbinom{n}{k}`).

For permutations use  $n^r$  from `n^{\underline{r}}` (some authors use  $P(n, r)$ , or  ${}_nP_r$  from `\{ \}_nP_r`).

**Statistics examples**

$$\sigma^2 = \sqrt{\sum (x_i - \mu)^2 / N} \quad \sigma^2 = \sqrt{\sum (x_i - \mu)^2 / N}$$

$$E(X) = \mu_X = \sum (x_i - P(x_i)) \quad E(X) = \mu_X = \sum (x_i - P(x_i))$$

The probability density of the normal distribution

$$\frac{1}{\sqrt{2\sigma^2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

comes from this.

$$\frac{1}{\sqrt{2\sigma^2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

**For more** See also the Comprehensive L<sup>A</sup>T<sub>E</sub>X Symbols List at [mirror.ctan.org/info/symbols/comprehensive](http://mirror.ctan.org/info/symbols/comprehensive) and DeT<sub>E</sub>Xify at [detexify.kirelabs.org/classify.html](http://detexify.kirelabs.org/classify.html).